



WAYMO

Driving
Autonomy
Forward -
Waymo's Vision
for Safer,
Smarter Mobility

Part 1 - Waymo's Safety Framework in Practice

Shilpa Gulati, Director of Safety and Compliance

OUR MISSION –

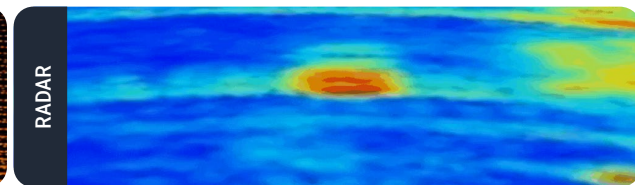
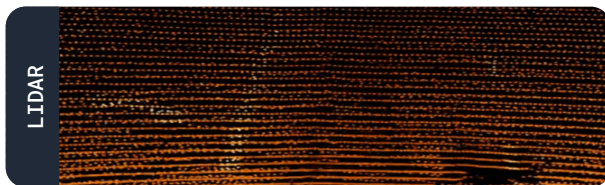
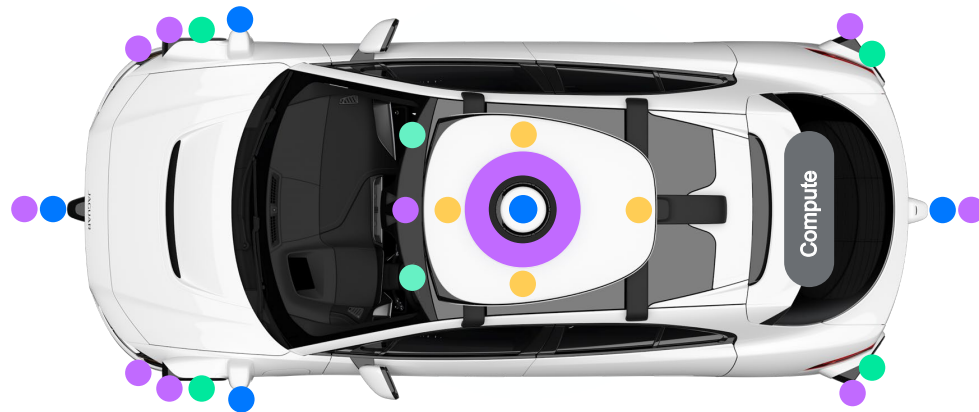
Be the world's
most trusted driver.

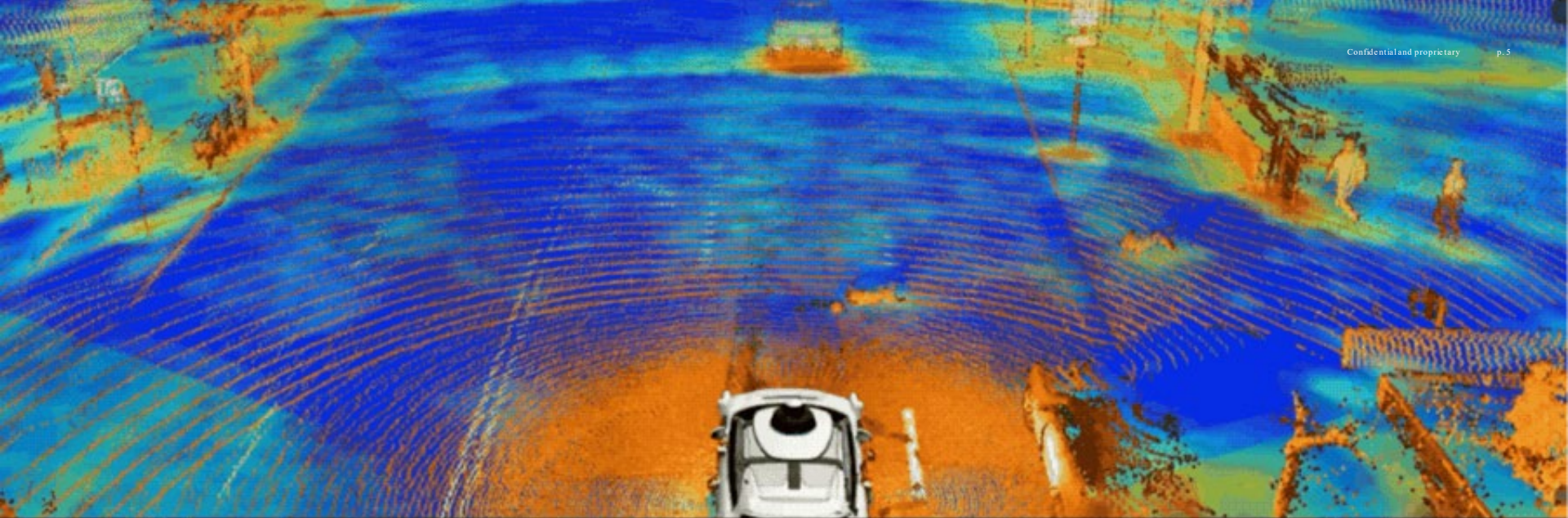


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The Waymo Driver

- Lidar system
- Vision system
- Radar system
- Microphone system





STEP 1

Where am I?



STEP 2

What's around me?



STEP 3

What will happen next?



STEP 4

What should I do?





Autonomously navigating the ordinary and the extraordinary

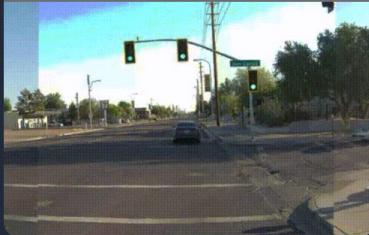
CROWDS



FALLING SKATERS



RED LIGHT RUNNERS



OFF-LEASH DOG



FLOOD



FALLING TREES



CYCLISTS



CAR CRASHES



FIRST RESPONDERS



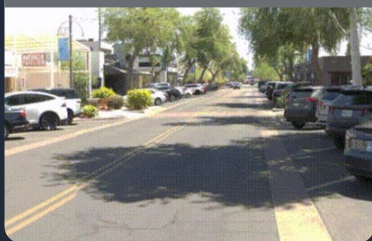
PEOPLE EXITING MOVING CARS



TODDLERS ON THE RUN



OCCLUDED PEDS



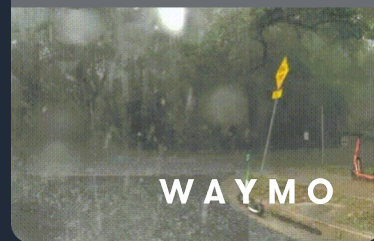
BOUNCE HOUSE



ROAD DEBRIS



HAIL



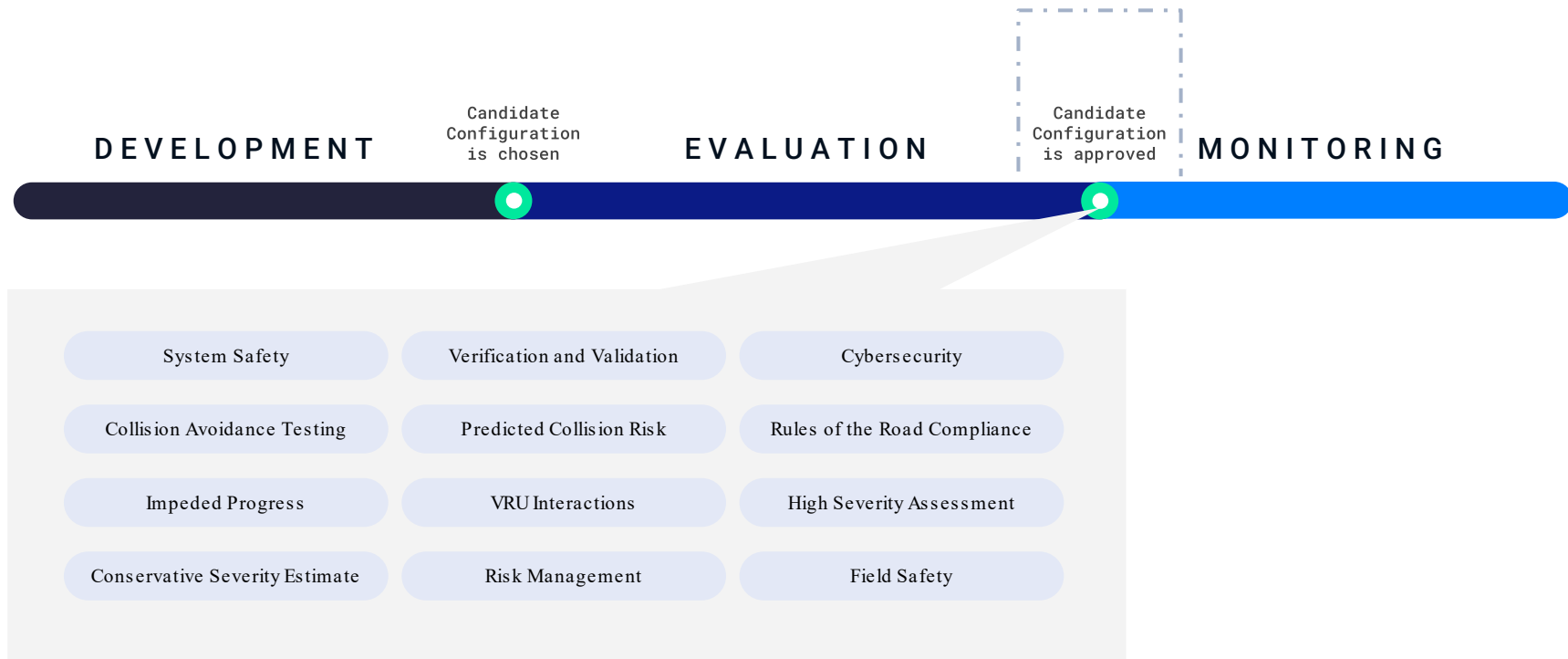
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A Snapshot of the Engineering Lifecycle

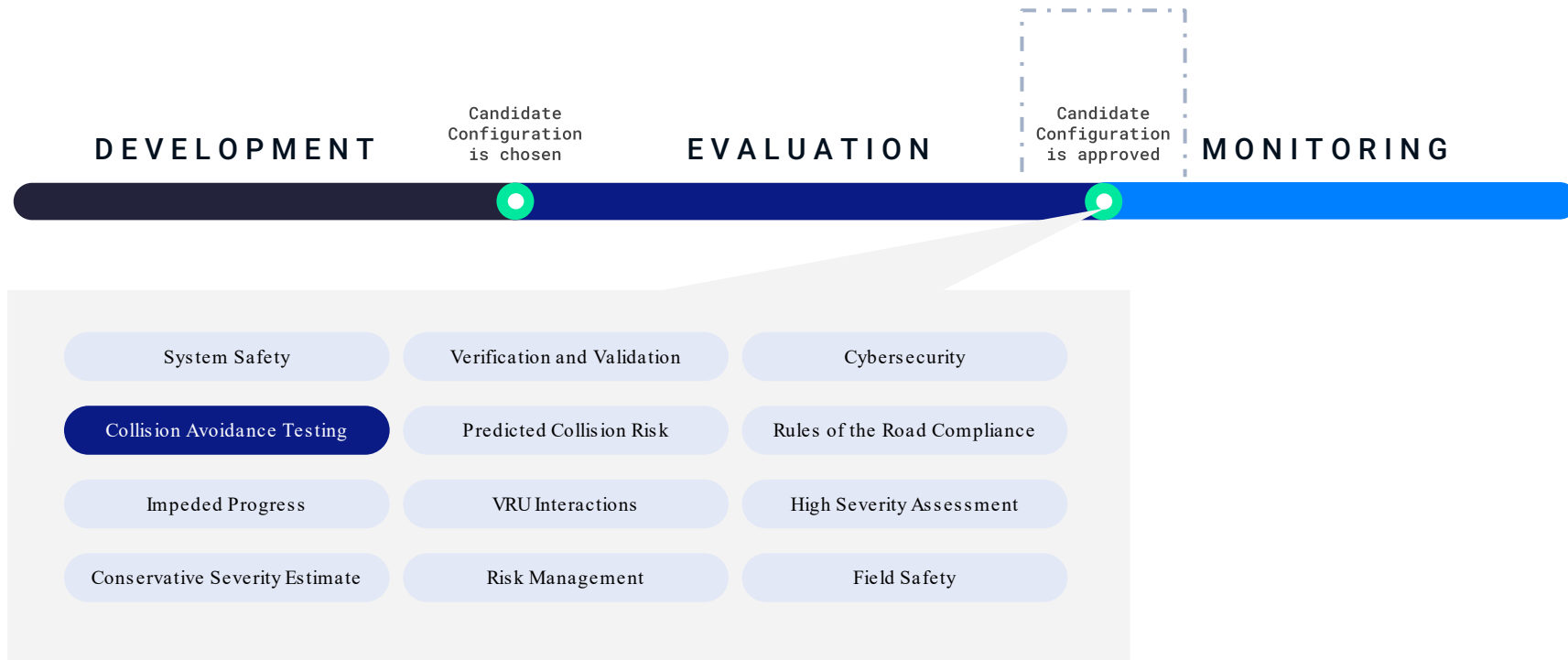
Three phases:



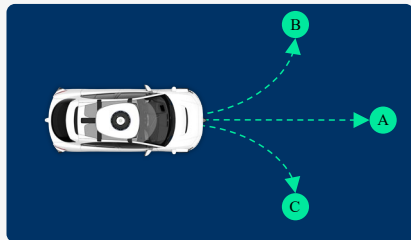
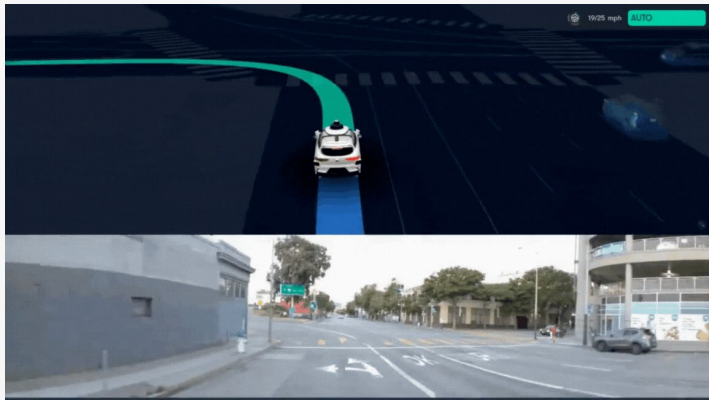
Waymo's Safety Framework and supporting methodologies



Collision Avoidance Testing (CAT)

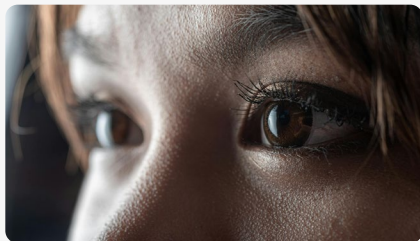


Collision Avoidance Testing (CAT)



Three chances given
(best outcome selected):

- A. Brake only
- B. Brake + steer left
- C. Brake + steer right



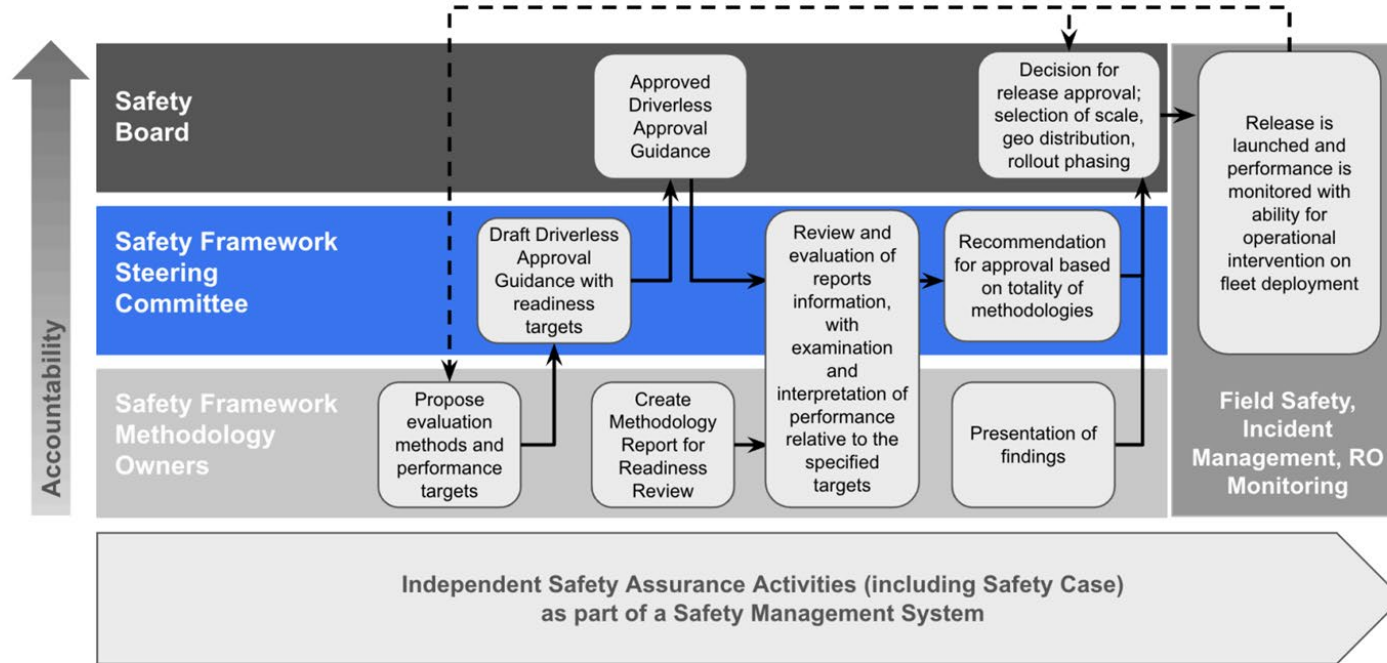
Attentive with eyes
always on the conflict

- Virtual, **scenario -based testing** methodology that evaluates ADS's ability to avoid situations initiated by others that require urgent evasive maneuvers.
- Compared to the “NIEON” model: Non-Impaired Eye on Conflict artificial driving model.
- Representative of a given ODD, informed by our driving experiences, public crash datasets, expert knowledge, etc.

Kusano, K., Beatty, K., Schnelle, S., Favaro, F., Crary, C., and Victor, T. (2022). Collision Avoidance Testing of the Waymo Automated Driving System. [arXiv:2212.08148](https://arxiv.org/abs/2212.08148)

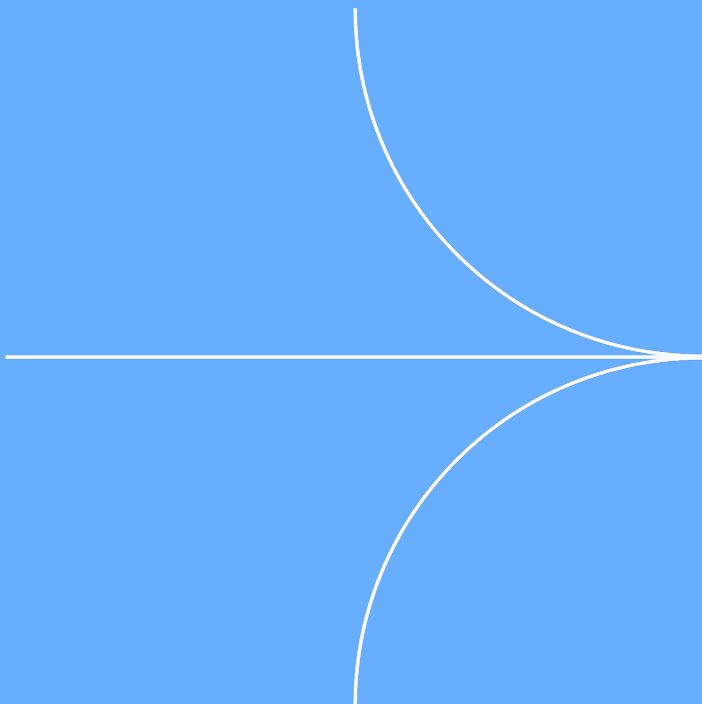
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Waymo's Safety Governance



Part 2 - Waymo's Safety Leadership

Chris Gerdes, Field Safety Architect



50m injuries and 1.35m deaths worldwide

50% of deaths

are pedestrians, cyclists
and motorcyclists

Source: WHO



25/25 mph

AUTO



The Science behind Safety Impact

$$\frac{\text{Crashes}}{\text{Exposure (Miles)}} = \frac{a}{b}$$

Autonomous

VS

$$\frac{\text{Crashes}}{\text{Exposure (Miles)}} = \frac{c}{d}$$

Human

Why is it hard to make fair comparisons?

Underreporting

- Many minor collisions are not reported

- Reporting is more consistent when

 - Injuries occur

 - Airbags deploy

Geographic differences

- Collision rates vary within and across cities

- Calculate human rates for miles Waymo Driver drove

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Compared to an average human driver over the same distance in our operating cities, the Waymo Driver had

Overall crash reduction



91%

Fewer serious injury or worse crashes

↓ 20 FEWER



79%

Fewer airbag deployment crashes

↓ 125 FEWER



80%

Fewer injury-causing crashes

↓ 304 FEWER

Crash reductions involving injuries to Vulnerable Road Users



92%

Fewer pedestrian crashes with injuries

↓ 35 FEWER



78%

Fewer cyclist crashes with injuries

↓ 22 FEWER



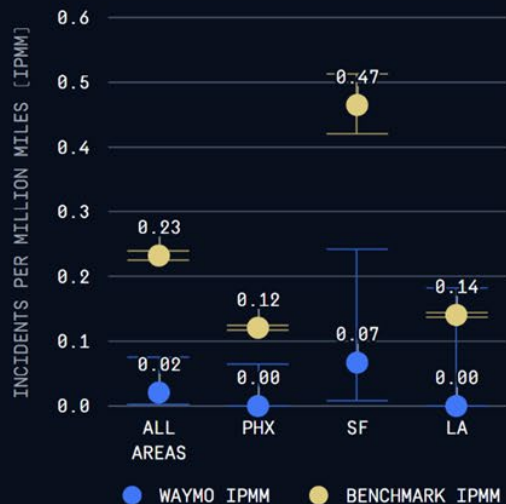
89%

Fewer motorcycle crashes with injuries

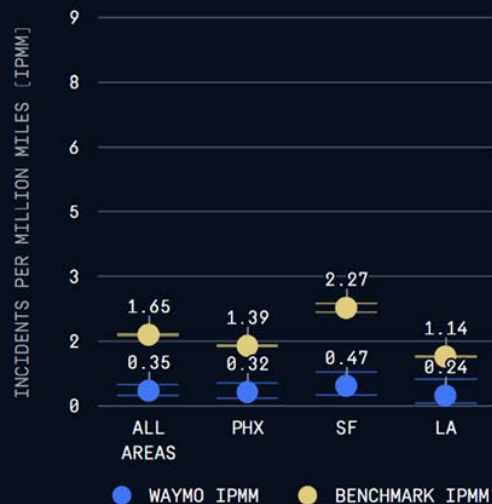
↓ 16 FEWER

Crash rates vary by location

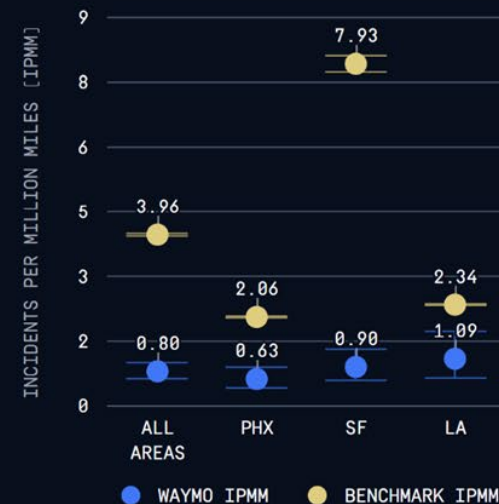
Serious Injury or Worse Crash Rates



Airbag Deployment Crash Rates

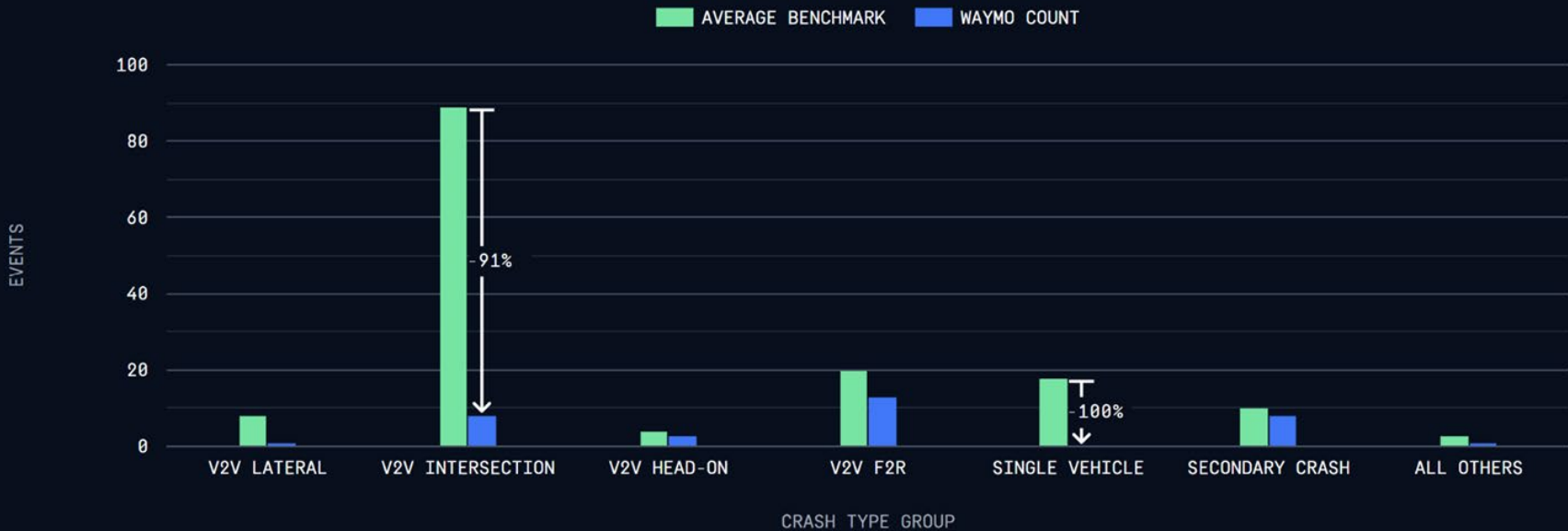


Any-Injury-Reported Crash Rates



Crash rate reduction by crash type - airbag deployments

Airbag Deployment Crashes

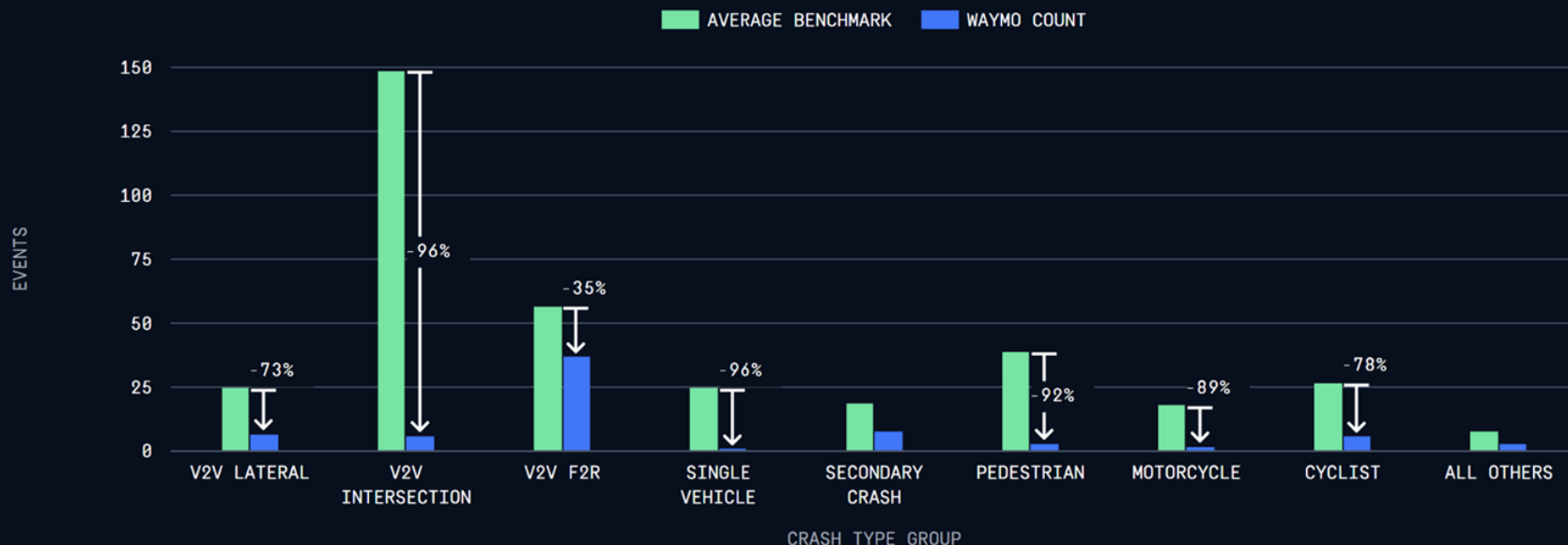


V2V = Vehicle-to-vehicle

*Bars showing a numeric % difference are statistically significant

Crash rate reduction by crash type - any injury reported

Any-Injury-Reported Crashes



V2V = Vehicle-to-vehicle

*Bars showing a numeric % difference are statistically significant

Safety Leadership

Transparency

- Data and publications on Waymo website

 - Includes human benchmark for driven miles

- NHTSA SGO reporting narratives

- Methodologies and standardization

Audits

- TÜV SÜD audit of Safety Case and Remote Assistance

- Previous evaluation of Waymo's First Responder Program

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Thank you

<https://waymo.com/safety>

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